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Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,286,880,** on October 15, 1999, by **FANTOM TECHNOLOGIES INC.,** assignee of Wayne Ernest Conrad, for "Method of Discharging Secondary Batteries".

CA00/01183

PRIORITY DOCUMENT

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ABSTRACT OF THE DISCLOSURE

A method and apparatus are provided for charging secondary batteries. The method comprises modifying a DC voltage to form a pulse train, and supplying the modified DC voltage to the secondary cell. Additionally, with one or more parameters, such as frequency, pulse width and amplitude, the pulse train can be selected and optimized, to optimize charging of the battery.

B&P File No. 5562-841

BERESKIN & PARR CANADA

Title: METHOD OF DISCHARGING SECONDARY BATTERIES

Inventor: Wayne Ernest Conrad

Title: METHOD OF DISCHARGING SECONDARY BATTERIES

FIELD OF THE INVENTION

This invention relates to a method and apparatus for discharging secondary cells or batteries.

BACKGROUND OF THE INVENTION

Secondary cells or batteries, as compared to primary cells, are designed to be capable of a large number of cycles of charging and discharging. A wide variety of secondary cells or batteries are known. For example, one common design is a so-called nickel-cadmium battery. This is a sealed battery having nickel anode, a cadmium cathode, and an alkaline electrode.

Like all batteries or cells, it delivers a DC current. Accordingly, charging of such secondary cells is commonly done by connection to a suitable, fixed DC potential. Current flow into the cell is then determined by the electrical characteristics of the cell, including the internal resistance of the cell. Practically, when charging the cell, the current initially has a relatively high value, and then reduces down, in some approximate exponential fashion.

Similar characteristics can be observed when discharging the cell, and all secondary cells have characteristic curves indicating the potential provided vs. charge remaining. Additionally, the potential available will depend upon the current being drawn from the cell, which in turn depends upon the cell's internal resistance.

The available power or charge than can be withdrawn from a cell will depend upon the discharge characteristics, and in particular whether a small or large current is drawn from the cell.

SUMMARY OF THE INVENTION

What the present inventor has realized is that both for

charging and discharging a battery, conventional techniques lead to much wastage of energy. Conventionally, as noted above, both for charging and discharging, current is drawn off essentially as a constant DC current. For practical applications, discharging will often result in a varying or intermittent current; but the essentially DC nature of the discharge certainly does not amount to a pulsed discharge as taught by the present invention and as detailed below.

What the present inventor has realized is that, for both charging and discharging, one can identify an apparent resonant effect. At the atomic level, it is believed that charging and discharging essentially requires ionization (or the reverse) of individual atoms or molecules. If such ionization is effected by application of a constant DC potential, often ionization is effected at a less than optimum state, thus requiring excess energy and wastage of energy. On the other hand, if ionization is, in effect, synchronized with an optimum state of the particular atom or molecule, then less energy is required.

At a macroscopic level, the inventor has discovered that this appears as a resonant effect. Thus, for discharging, the inventor has discovered that if the series or train of pulses is applied during the discharging process, then much more efficient discharging can be obtained, that is the total amount of power or charge taken from the secondary battery can be significantly increased. In effect, between each pulse, the battery or cell is permitted to relax, and when the next pulse is applied, atoms or molecules are in an optimum state for discharging, without wasting any of the stored energy.

BRIEF DESCRIPTION OF THE DRAWING FIGURE

For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, which shows a preferred embodiment of the present invention and in which:

Figure 1 is a schematic of an apparatus in accordance with

the present invention; and

Figure 2 is a graph showing an exemplary pulse train over one period.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Figure 1, there is shown an apparatus in accordance with the present invention, the apparatus including a basic connector unit 1, as is common for any battery powered device.

Leads 4 connect the DC output signal from the connector unit 1 to an electronic control unit 5 in accordance with the present invention. As detailed further below, the electronic control unit 5 is adapted to modulate the DC signal with a pulse train.

The electronic control unit 5 is connected by leads 6 to a load 7. As for conventional chargers, the connector unit 1 is adapted to receive at least one secondary cell, and preferably adapted to receive a plurality of such secondary cells as indicated at 8.

The electronic control unit 5, as mentioned, is adapted to modulate the DC signal received through the wires or leads 4 with a pulse train. This pulse train essentially comprises a sequence of a large number of pulses, each of which can have differing characteristics, in terms of pulse widths and pulse height or voltage amplitude. The period between the pulses or pulse frequency is constant over the complete cycle. At least one, and preferably two, of these parameters (pulse width, frequency and voltage) can be selected and then modified to give the best result.

The complete cycle of pulses is continuously repeated, so as to provide a continuous pulse train.

What the inventor has discovered is that there is an algorithm relating the parameters of the pulse train to the charging behaviour of the cells 8. The principal parameters of the pulse train are: frequency, pulse width, and voltage or pulse height. Here, it is assumed that the pulses have a generally sinusoidal shape, but in general rectangular or other pulse profiles are expected to be suitable.

Various strategies can be used to examine this algorithm or determine its characteristics. For example, while maintaining the voltage constant, the pulse width and frequency can be varied.

The attached figure 2 shows an exemplary profile of the pulse train or signal provided by the electronic control unit 5. This shows a single period or cycle 20, and it will be understood that this period 20 is repeated to form the continuous signal.

Figure 2 shows exemplary pulse wave forms over a period 20. Within this period 20, there are 5 individual pulses, labelled 21, 22, 23, 24 and 25. Following each pulse, there is a respective pulse interval, labelled at 21a, 22a, 23a, 24a and 25a. In this example, these intervals have the parameters given in the following table and shown in the drawing.

TABLE 1

Pulse Number	Pulse Voltage	Pulse Duration	Pulse Interval
21	1.3	0.7	4 ms
22	1.4	0.8	5 ms
23	1.5	0.9	6 ms
24	1.6	0.1	7 ms
25	1.9	0.1	10 ms

As this table shows, within the period 20, all the parameters of the pulses, namely frequency (i.e. inverse of the pulse interval), pulse width or duration, and pulse height (voltage) are varied. This gives a distinct pulse profile for the period, and this is repeated in following periods. In general, depending on the particular application, it may not be necessary to vary all three parameters, and it may be sufficient to vary just two of them, or even just one of them, with the other(s) being kept constant. Additionally, it will be understood that the absolute magnitude of

each of these parameters can vary greatly depending upon the actual application. Also, a variety of pulse profiles can be used.

CLAIMS:

1. A method of charging a secondary cell, the method comprising: supplying a DC voltage as a series of pulses to the secondary cell.

2. A method as claimed in claim 1, wherein the method comprises selecting values at least two of the frequency, pulse width and amplitude of each pulse, to optimize charging of the battery.

3. A method as claimed in claim 2, which includes selecting values of all of the frequency, pulse width and amplitude of the pulses, to optimize charging of the battery.

4. A method as claimed in claim 1, 2 or 3, which includes providing the pulses as a continuous pulse train comprising a plurality of consecutive periods, wherein each period comprises a plurality of pulses, wherein the value of at least one of the frequency, the pulse width and the pulse amplitude varies within each period, and wherein all of the periods have substantially identical pulse profiles.

5. An apparatus for charging a battery, the apparatus comprising:

an electronic control unit for generating a pulse train; and

a charge device, for providing a connection to secondary cells.

6. An apparatus as claimed in claim 5, wherein the electronic control unit includes means for selectively setting at least two of the frequency, pulse width and pulse height of the pulse train.

7. An apparatus as claimed in claim 6, wherein the electronic

control unit includes means for generating the pulse train as a plurality of consecutive periods, wherein each period comprises a plurality of pulses, wherein the value of at least one of the frequency, the pulse width and the pulse amplitude varies within each period, and wherein all of the periods have substantially identical pulse profiles.

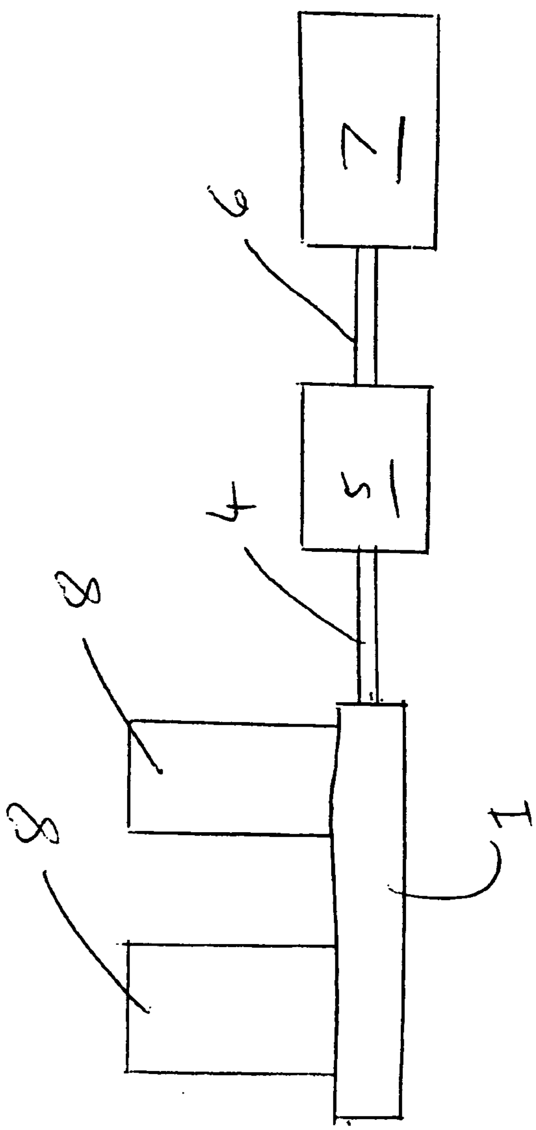
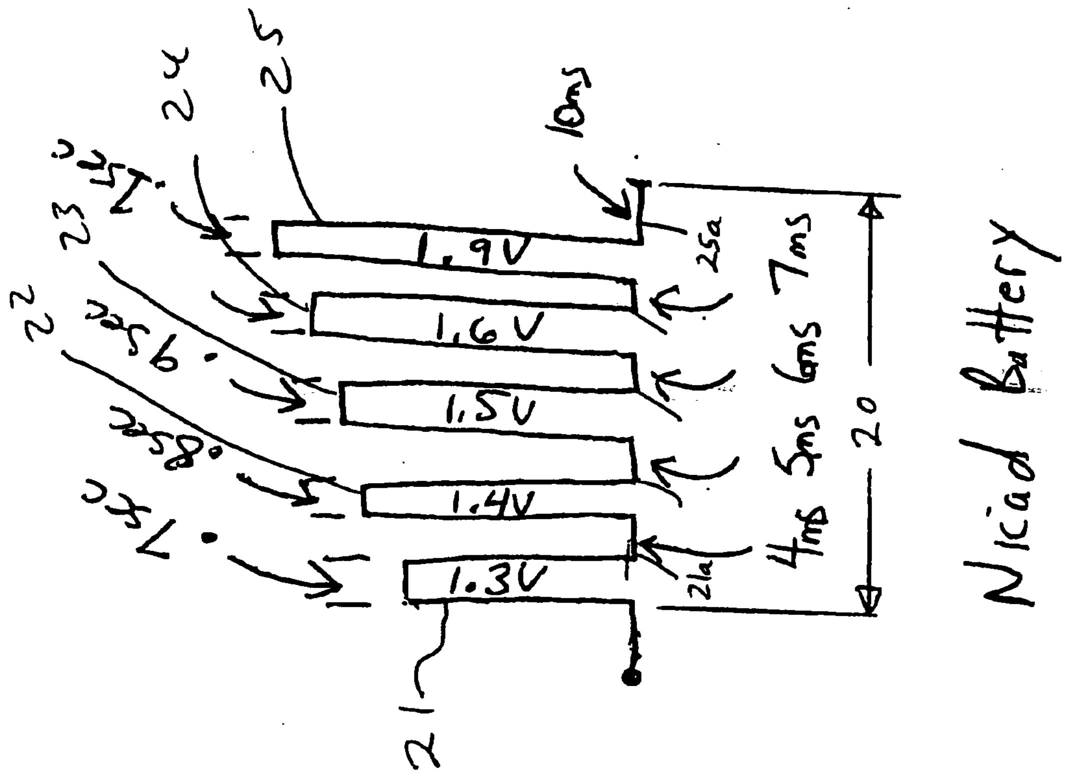


Figure 1

Figure 2


1.9V
1.6V
1.5V
1.4V
1.3V
10ms
4ms 5ms 6ms 7ms
20
21
21a
22
23
24
25
25a
.75sec
.85sec
.95sec
Nicad Battery